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VERIFICATION OF TRANSLATION

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I verify that the attached English translation is a true and correct translation made by me of the specification in the German language of German patent application No DE 10318157;

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment or both under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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Film and optical security element

The invention concerns a substrate, in particular a film, a stamping film, a laminating film or a sticker film, having a carrier layer and a replication layer. The invention further concerns an optical security element for safeguarding banknotes, credit cards and the like, which has a replication layer.

In the sector of liquid crystal display technology, alignment or orientation of liquid crystal polymers (Liquid Crystal Polymers = LCP) to orientation layers is known. Here, mainly a polyimide layer is oriented by a mechanical brushing process. In a second step in the process, liquid crystal polymers are applied to the orientation layer, and they then align themselves to that orientation layer.

In addition EP 1 227 347 describes the alignment of LCPs to a photopolymer layer.

In that case, a first orientation layer is printed on to a substrate by means of an ink jet printer, the orientation layer comprising a photopolymer which can be aligned into a given orientation direction by irradiation with polarised light. That layer is now irradiated with polarised light. Then, a layer of a liquid crystal material is applied to the orientation layer by means of an ink jet printer and conditions are provided, under which the liquid crystal material is oriented. The liquid crystal layer is then hardened by means of UV-light.

In that case it is also possible for two orientation layers to be applied to a substrate in mutually superposed relationship. In that case, the two layers are each irradiated with differently polarised light and then fixed so that the result is orientation layers involving different orientations, which are arranged one over the other. Regions involving differing orientation can

be produced by that multiple coating procedure in combination with a suitable, pattern-shaped configuration of the individual photopolymer layers which are arranged in mutually superposed relationship.

WO 01/60589 proposes introducing mutually intersecting grooves into an orientation layer for LCD displays, by means of a cutting tool. In that region, that procedure provides for orientation of a part of the molecules in one direction and orientation of another part of the molecules in the other direction.

Now, the object of the present invention is to improve the production of optical security elements and/or decorative films.

The object of the invention is attained by a substrate, in particular a film, a stamping film, a laminating film or a sticker film, which has a carrier layer, a replication layer and a layer of a liquid crystal material, which is applied to the replication layer, and wherein impressed into the surface of the replication layer, which is towards the layer of a liquid crystal material, is a diffractive structure for orientation of the liquid crystal material, which has at least two partial regions with different orientation directions in respect of the impressed structure.

The object of the invention is further attained by an optical security element for safeguarding banknotes, credit cards and the like, having a replication layer and a layer of a liquid crystal material which is applied to the replication layer, and wherein impressed into the surface of the replication layer, which is towards the layer of a liquid crystal material, is a diffractive structure for orientation of the liquid crystal material, which has at least two partial regions with different orientation directions in respect of the impressed structure.

The invention makes it possible for liquid crystals to be oriented in a region in a purposeful manner and with a high degree of precision in different orientation directions, whereby it is possible to produce various different optical security features which are visible only under polarisers and which thus have obvious but easily detectable properties. That makes it possible to achieve a high degree of security against forgery. In addition the production process is simplified, speeded up and made less expensive.

Thus for example when using photopolymers, it is necessary to effect numerous complicated and expensive exposure steps and/or produce expensive masks.

In this respect, liquid crystals in monomeric and polymeric form can be used as the liquid crystal material.

Advantageous configurations of the invention are set forth in the appendant claims.

Optical security features which are particularly forgery-proof can be achieved if the diffractive structure has a region which is coated with the layer of a liquid crystal material and in which the orientation direction of the structure progressively changes. When a security feature produced by means of such a diffractive structure is considered through a polariser with for example a rotating polarisation direction, various, clearly recognisable security features, for example movement effects, can be produced by virtue of the linearly changing polarisation direction of the security element.

In addition it is also desirable for mutually adjoining regions which are coated with the layer of a liquid crystal material to be provided with different orientation directions in respect of the diffractive structure.

In addition it is possible for the diffractive structure to have a first region for the orientation of liquid crystal material, which is covered by the layer of a liquid crystal material, and for the diffractive structure to have a second region for producing an optical diffraction effect, for example for producing a hologram or a kinoform. In that way, a security feature which is based on a polarisation effect and a security feature which is based on a diffraction effect are produced in mutually juxtaposed relationship in one and the same layer. It is possible in that way to achieve a security element with a high degree of safeguard against forgery, combined with low production costs. In that way, that affords the basis for two different optical effects, by means of one and the same method step.

It is particularly advantageous in that respect that the polarisation representation produced in the first region and a holographic representation produced in the second region form a mutually supplemental representation. For example, the holographic representation represents a

tree, the leaves of which are formed by the polarisation representation. The contents of the polarisation representation and the holographic representation thus supplement each other in such a way that a change in one of the representations immediately becomes visible from the other representation. That further enhances the level of safeguard against forgery.

It has further proven to be advantageous to use a diffractive structure which is formed from the superimposition of a first structure for producing an optical effect and a second structure for orientation of the liquid crystal material. It has been found that adequate orientation of the liquid crystal molecules by the superimposed second structure is possible if that second structure is of a higher spatial frequency than the first structure and/or is of a greater profile depth than the first structure. In that respect, particularly good orientation effects can be achieved if the spatial frequency of the second structure is at least ten times higher than the spatial frequency of the first structure or if the spatial frequency of the second structure is greater than 2500 lines per mm.

The application of that basic principle makes it possible to generate a multiplicity of novel, optically variable elements which on the one hand exhibit a polarisation-independent optical effect produced by a macrostructure, a matt structure, a hologram or a kinoform, and which on the other hand exhibit a polarisation effect generated by oriented liquid crystals.

The combination with an isotropic matt structure (scattering does not involve a preferential direction) affords the advantage that any difference in refractive index which may be present between the replication layer and the liquid crystal material or shadow effects or veiling effects caused by faults or discontinuities in the orientation of the liquid crystals are compensated and are no longer visible. An additional copy protection is also afforded in that way. Scattering of the polarised light prevents the production of a sufficiently fault-free orientation layer by an exposure process based on photopolymers.

It is further desirable if the layer of a liquid crystal material covers the diffractive structure only in a region-wise manner in a pattern configuration. That affords further design options.

It has proven to be advantageous to provide a protective lacquer layer which covers the layer of a liquid crystal material.

It is further advantageous to vary the profile depth of the diffractive structure and to use that to produce colour effects which are only visible under the polariser.

In accordance with a preferred embodiment of the invention the film has a further layer with a further, optically effective, diffractive structure, or a further, optically effective, diffractive structure is impressed on the surface of the replication layer, which faces away from the layer of a liquid crystal material. That optically effective, diffractive structure makes it possible to achieve further combinations of diffraction-optical security features and security features which are visible only in polarised light. If the further, optically effective, diffractive structure overlies in a region-wise manner the diffractive structure which acts as an orientation layer, superimposition of effects of that kind can be achieved. In addition, arranging the two diffractive structures in accurate register relationship makes it possible to provide that the items of information optically represented by those structures supplement each other in terms of the content thereof.

A further possible way of increasing the degree of safeguard against forgery provides that the film additionally has a thin film layer system and/or other security features, such as for example partial demetallisation. There is also the possibility of providing a reflecting layer, in particular a metallic layer, or an HRI layer, so that the security element can be in the form of a reflective or partially reflective security element. In addition (partial or full-area) cholesteric liquid crystal layers can also serve as a reflector.

The combination of the layer comprising a liquid crystal material with the above-described layers having an optical diffraction effect, interference layers and/or reflective layers makes it possible to provide an optical

security element with a high degree of safeguard against forgery, the security features of which are strongly interwoven with each other by virtue of their superimposition or mutual supplementing, and thus make manipulation more difficult. A further advantage lies in the possibility of superimposing security features which can be seen with the human eye, with security features which can be detected only under polarised light, and thus superimposing a non-obvious, machine-readable security feature.

There is also the possibility of designing an optical security element in the form of a two-part security element, in which a partial element has the replication layer and the layer of a liquid crystal material and a second partial element has a polariser for checking the security feature produced by the layer of a liquid crystal material. In that way it is possible for the user to check the security feature which cannot be recognised with the naked eye, by viewing the first partial element by way of the second partial element.

Further advantages are afforded if both partial elements have a layer of a liquid crystal material, which is applied to a respective replication layer into which a diffractive structure for orientation of the liquid crystal material is impressed and which has at least two partial regions with different orientation directions in respect of the impressed structure. The security elements of the two partial elements supplement each other so that, by viewing the first partial element by way of the second partial element, it is possible for the user to check the security feature, which is not visible to the naked eye, of the first partial element.

The invention is described by way of example hereinafter by means of a number of embodiments, with reference to the accompanying drawings in which:

Figure 1 is a diagrammatic view of a security document provided with an optical security element according to the invention,

Figure 2 shows a section through a stamping film according to the invention,

Figure 3 shows a section through a sticker film according to the invention,

Figure 4 shows a diagrammatic sectional view of an optical security element according to the invention applied to a value-bearing document or bond,

Figure 5a shows a plan view of an optical security element according to the invention,

Figure 5b shows a sectional view of the security element of Figure 5a,

Figures 6a to 6e show diagrammatic views of diffractive structures for the orientation of liquid crystal molecules,

Figure 7 shows a sectional view of a film according to the invention in a first embodiment,

Figure 8 shows a sectional view of a film according to the invention for a second embodiment, and

Figure 9 shows a sectional view of an optical security element according to the invention for a third embodiment.

Figure 1 shows a security document 1 which comprises a carrier element 13 and an optical security element comprising two partial elements 11 and 12.

The security document 1 is for example a banknote, an identity card or pass, a ticket or a software certificate. The carrier element 13 comprises for example paper or a flexible plastic material.

The partial element 12 comprises a polariser which is let into a window in the carrier element 13 or which is applied to a transparent region of the carrier element 13. By bending the carrier element 13, it is possible for a user to view the partial element 11 through the partial element 12 and thus to make polarisation effects produced by the partial element 11 visible.

It is also possible to forego the partial element 12 and only apply the partial element 11 to the security document.

In that case the carrier element 13 can also comprise a non-flexible material so that the security document 1 is for example a credit card. In that case the carrier element 13 comprises a conventional plastic card, on the front side of which is impressed for example the name of the card

holder. In that respect it is possible for that plastic card, in the region of the optical security element, to have a transparent region, so that the optical security element can be a transmissive optical security element.

Reference will now be made to Figures 2 to 9 to set out various options in regard to production and possible configurations of an optical security element according to the invention which can also be used as the partial element 11 in Figure 1.

Figure 2 shows a stamping foil 2 having six layers 21, 22, 23, 24, 25 and 26.

The layer 21 is a carrier layer which is for example of a thickness of about 12 μm to 50 μm and which is formed by a polyester film. The layers 22, 23, 24, 25 and 26 form the transfer layer of the stamping film 2.

The layer 22 is a release or protective lacquer layer which is preferably about 0.3 to 1.2 μm in thickness. It would also be possible to forego that layer.

The layer 23 is a replication layer into which diffractive structures can be impressed by means of an embossing or stamping tool. In this case the replication layer 23 preferably comprises a transparent thermoplastic material which can be applied for example by a printing process.

In this case the replication lacquer is for example of the following composition:

Component	Parts by weight
High-molecular PMMA resin	2000
Silicone alkyd oil-free	300
Non-ionic wetting agent	50
Low-viscosity nitrocellulose	750
Methylethylketone	12000
Toluene	2000
Diacetone alcohol	2500

The carrier layer 21 comprises for example a PET film of a thickness of 19 μm, to which the above-indicated replication lacquer is applied with a line raster intaglio printing cylinder, more specifically with an application

weight of 2.2 g/m^2 after drying. Drying is effected in the drying passage at a temperature of 100 to 120°C.

The diffractive structure 27 is then impressed into the layer 23 at about 130°C by means of a female die which for example consists of nickel. The die is preferably electrically heated for embossing the diffractive structure 27. The die can be cooled down again before it is lifted off the layer 23 after the embossing operation. After the diffractive structure has been impressed, the replication lacquer hardens by cross-linking or in some other fashion.

The layer 24 is a layer of a liquid crystal material (LC = Liquid Crystal). The layer 24 is preferably from 0.5 μm to 5 μm in thickness. In principle it is possible to use all possible kinds of liquid crystal materials which have the desired optical properties. Examples in that respect are liquid crystal materials of the OPALVA ® series from Vantico AG, Basle, Switzerland.

The liquid crystals are then aligned or oriented to a layer 23 serving as the orientation layer, with the application of some heat. UV-hardening of the liquid crystal material is then effected to fix the orientation of the liquid crystal molecules.

In addition it is also possible for the layer which has been applied by printing and consisting of a solvent-bearing liquid crystal material to be subjected to a drying process and for the liquid crystal molecules to be oriented during evaporation of the solvent, in accordance with the diffractive structure 27. It is also possible for solvent-free liquid crystal material to be applied by a printing process and fixed after orientation by cross-linking.

The layer 25 is a protective lacquer layer which is applied to the layer 24 for example by a printing process. It would also be possible to forego the layer 25. The layer 25 is for example from 0.5 μm to 3 μm in thickness and preferably comprises UV-cross-linkable acrylates and abrasion-resistant thermoplastic acrylates.

The layer 26 is an adhesive layer which for example comprises a thermally activatable adhesive.

For the purpose of applying the stamping film 2 to a security document or to an article to be safeguarded, the stamping film 2 is applied to the security document or the article to be safeguarded with the transfer layer portion formed by the layers 21 to 26 leading, and is then pressed against the security document or the article to be safeguarded, under the effect of heat. In that case, the transfer layer portion is joined by way of the adhesive layer 26 to the corresponding surface of the security document or the article to be safeguarded. In addition, as a consequence of the production of heat, the transfer layer portion is detached from the carrier layer 21. Detachment of the transfer layer portion from the carrier layer 13 is facilitated in that respect by the preferably wax-like separation layer 22.

The stamping film 2 may also involve a different kind of film, for example a laminating film. In that case the layer 22 would be replaced by a further layer which possibly improves the adhesion to the carrier.

Figure 3 shows a sticker film 3 comprising four layers 31, 32, 33 and 34.

The layer 31 is a carrier layer which for example comprises a transparent, partly transparent or non-transparent polyester material of a thickness of 12 μm to 15 μm. The layer 32 is a replication layer into which a diffractive structure 35 is impressed. The layer 33 is a layer of a liquid crystal material and the layer 34 is a protective lacquer layer. In this case the layers 32, 33 and 34 can be of a nature like the layers 23, 24 and 25 in Figure 2. It would also be possible to forego the layer 34.

Figure 4 shows an optical security element 4 and a substrate 46 to which the optical security element 4 is applied. The substrate 46 is for example a security document to be safeguarded, for example the basic element 13 shown in Figure 1. The optical security element 4 has five layers 41, 42, 43, 44 and 45. The layer 41 is a protective lacquer layer. The layer 42 is a replication layer into which a diffractive structure 46 is impressed. The layer 43 is a layer of a liquid crystal material, the layer 44 is a protective lacquer layer and the layer 45 is an adhesive layer which

glues the layer 44 to the substrate 46. The layers 41 to 45 are for example of the same nature as the layers 21 to 26 of Figure 2.

Reference will now be made to Figure 5 to set forth further possible ways in which the diffractive structures 27, 35 and 46 are to be formed.

Figure 5 shows an optical security element 6 which can be divided into a plurality of regions 61, 62 and 63.

The regions 61, 62 and 63 are embossed over their full area with a diffractive structure. The diffractive structure comprises for example a plurality of mutually juxtaposed parallel grooves which permit orientation of liquid crystal molecules. By way of example, those grooves are of a spatial frequency of 300 to 3000 lines/mm and involve a profile depth of 200 to 600 nm. Shallower depths are also possible, for example in the region of 50 nm. In that respect, particularly good orientation results can be achieved by diffractive structures, the spatial frequency of which are established in the range of 1000 to 3000 lines/mm. In this case, the longitudinal direction of those grooves represents the orientation direction of the diffractive structure.

It is further possible to vary the profile depth of the grooves. When the liquid crystal material is applied, for example by means of a doctor or squeegee, that produces differing thicknesses of the layer of a liquid crystal material, in different regions of the film. That leads to the production of colour effects which are visible only under the polariser.

Those effects can further be produced by the use of deep grooves which are filled in the printing process for example to differing heights with liquid crystal material (for example by a suitable raster or patterning roller with differing application weight and/or by using a chamber-type or comb-type squeegee).

Kaleidoscope or iridescence effects and patterns can also be produced by using suitable carrier materials, for example by birefringence. In that respect, by specific and purposeful adjustment of the orientation direction of the liquid crystal material, it is also possible to achieve an attractive kaleidoscope or iridescence effect or play of colours, which is afforded by the interaction of the liquid crystals with the structured carrier

material (for example by a variation of the angles in the structure layer or by forming guilloche figures).

The orientation direction of the diffractive structure is different in the regions 61, 62 and 63. Thus the region 61 for example has a plurality of parallel, horizontally arranged grooves, the region 62 has a plurality of vertically arranged, parallel grooves and the region 63 has a plurality of parallel grooves which are tilted through 30° with respect to the vertical. In that way the diffractive structure is oriented horizontally in the region 61, vertically in the region 62 and tilted through 30° with respect to the vertical in the region 63.

It is further possible for the diffractive structure to be formed by a plurality of grooves, the orientation direction of which changes along the grooves. Thus for example the orientation direction of the diffractive structure can progressively change along the horizontal or vertical axis in the region 61. That makes it possible to achieve for example movement effects or grey scale variation patterns.

It is also possible for the optical security element 6 to have a plurality of regions involving differing orientation direction in respect of the impressed structure, the magnitude of which is preferably below the range which can be resolved by the human eye. Those regions form pixels of varying, mutually superposed polarisation representations which are more or less visible in dependence on the polarisation direction of the incident light.

It is further possible for diffractive structures for the orientation of liquid crystal material to be impressed only in the region 62 and for the diffractive structures in the regions 61 and 63 to serve for producing an optical diffraction effect, in particular for producing a hologram, a kinegram or the like.

As shown in Figure 6, the optical security element 6 thus has a replication layer 65, a layer 66 of a liquid crystal material and an adhesive layer 67. A diffractive structure 68 is impressed into the replication layer 65.

The replication layer 65, the layer 66 and the adhesive layer 67 are for example like the layers 23, 24 and 26 respectively shown in Figure 2.

As illustrated in Figure 6, the layer 66 is applied by printing to the replication layer 62 only in a region-wise manner in the region 62. The diffractive layer 68 is not coated with liquid crystal material in the regions 61 and 63 so that no polarisation effect is achieved by oriented liquid crystal molecules in those regions. Accordingly, a polarisation representation is only produced in the region 62. In the regions 61 and 63 in contrast, the optical diffraction effect produced by the diffractive structure 68 is effective.

Such a configuration provides that the optical security element 6 produces an optical representation which is composed of a polarisation representation in the region 62 and two flanking holographic representations in the regions 61 and 63.

Preferably those holographic representations and the polarisation representation are representations which supplement each other in terms of their content and which for example form a common word or a common graphic representation. Depending on the respective selected common image or the common word to be represented, two or more of the regions 61 to 63 can be arranged in mutually juxtaposed relationship in any representation. For example it is possible to image the representation of a holographic tree, the leaves of which are formed by polarisation representations and are thus recognisable only when viewed in polarised light or by way of a polariser.

It is further possible to use a diffractive structure which is afforded by the superimposition of a first structure for producing an optical effect and a second structure for orientation of the liquid crystal material. In that respect it has been found that orientation of the liquid crystal molecules by the second structure is possible if that second structure has a higher spatial frequency (coarse structure-fine structure) and/or a greater profile depth than the first structure.

That will now be described hereinafter with reference to Figures 6a to 6e showing diagrammatic views of diffractive structures 51 to 55 of that nature.

The diffractive structure 51 is an additive superimposition of a fine structure, for example a zero-order diffraction structure, and a microscopically fine, light-scattering coarse structure. The microscopically fine, light-scattering coarse structure is a structure from the group of isotropically or anisotropically scattering matt structures, kinoforms or Fourier holograms.

It is further also possible to use as the coarse structure a macrostructure which has a spatial frequency of less than 300 lines per mm so that the polarisation effect caused by the liquid crystals is overlaid by a polarisation-dependent optical effect produced by the macrostructure. For example sawtooth profiles or micro-lenses can be used as the macrostructures.

The diffractive structures 52 to 55 each have a structure which diffracts visible incident light, with a profile height whose relief function is a superimposition of a low-frequency grating structure G(x, y) with a high-frequency relief structure R(x, y). The low-frequency grating structure G(x, y) is of a known profile such as for example a sinusoidal, rectangular profile, or a symmetrical or asymmetrical sawtooth-shaped profile, and so forth. The high-frequency relief structure R(x, y) is of a spatial frequency f_R of preferably at least 2500 lines per millimetre. The low-frequency grating structure G(x, y) on the other hand has a low grating spatial frequency f_G of for example less than 1000 lines/millimetre. Preferably the grating spatial frequency f_G is of a value of between 100 lines/millimetre and 500 lines/millimetre.

The relief profile height h_R of the relief structure R(x, y) is of a value from the range of 150 nm to 220 nm; preferably however the relief profile height h_R is selected from the narrower range of 170 nm to 200 nm. The grating profile height h_G of the grating structure G(x, y) is to be selected to be greater than the relief profile height h_R. The grating profile height h_G is preferably of a value from the range of 250 nm to 500 nm.

The low-frequency grating structure G(x, y) diffracts the incident light in dependence on the grating spatial frequency f_G into a plurality of diffraction orders and accordingly produces an optical diffraction effect. The high-frequency relief structure serves for orientation of the liquid crystal material.

The diffractive structure B(x) shown in Figure 6b is the result of additive superimposition of the sinusoidal grating structure G(x) with the sinusoidal relief structure R(x), that is to say B(x) = G(x) + R(x). A grating vector of the grating structure G(x) and a relief vector of the relief structure R(x) are oriented substantially parallel.

Figure 6 shows a diffractive structure B(x) in which the grating vector and the relief vector are oriented in mutually orthogonal relationship in the plane of the co-ordinates x and y. For example the sinusoidal grating structure G(x) is only a function of the co-ordinate x while the sinusoidal relief structure R(y) is only dependent on the co-ordinate y. Additive superimposition of the grating structure G(x) with the relief structure R(y) affords the diffractive structure B(x, y) which is dependent on the two co-ordinates x, y, wherein B(x, y) = G(x) + R(y). For reasons relating purely to clarity of the drawing, in Figure 6c the interface with the troughs of the relief structure R(y), which are disposed one behind the other, are denoted by dot patterns of differing densities.

The diffractive structure B(x) in Figure 6d is a multiplicative superimposition B(x) = G(x) • {R(x) + C}. The grating structure G(x) is a rectangular function with the function values [0, h_G], a period of 4000 nm and a profile height h_G = 320 nm. The relief structure R(x) = 0.5 • h_R • sin(x) is a sine function with a period of 250 nm and a profile height h_R = 200 nm. C denotes a constant, wherein C = h_G - h_R. The diffractive structure 64 is modulated on the raised surfaces of the rectangular structure with the relief structure R(x), while the diffractive structure 64 on the bottom of the grooves of the rectangular structure is smooth.

In Figure 6e the multiplicative superimposition of the rectangular grating structure G(x) with the relief structure R(y) produces the diffractive structure B(x, y). The grating structure G(x) and the relief structure R(y)

have the same parameters as in the case of the diffractive structure 63, with the exception of the relief vector which points in the direction of the co-ordinate y.

It is also further possible for the films 2 and 3 and the optical security elements 4 and 6 to have further layers into which are impressed further, optically effective, diffractive structures. The further layers can be of metal, they can form a thin film layer system for the production of colour shifts by means of interference and/or they may have reflecting properties. Further advantageous effects can be achieved by a partial provision of those layers.

Some possible ways of providing such further layers in the films 2 and 3 and the security elements 4 and 6 will now be described with reference to Figures 7 to 9.

Figure 7 shows a stamping film 7 comprising a carrier layer 71 and a transfer layer portion comprising layers 72, 73, 74 and 75. The layer 72 is a protective lacquer layer. The layer 73 is a replication layer into which diffractive structures 761, 762 and 763 are impressed. The layer 74 is a reflective layer and the layer 75 is an adhesive layer.

The stamping film 7 has regions 771 to 774 in which the stamping film is of different configurations.

The layers 71, 72, 73 and 75 are like the layers 21, 22, 23 and 26 respectively. The layer 74 is a thin, vapour-deposited metal layer or an HRI layer (HRI = High Refraction Index). The material to be considered for the metal layer is essentially chromium, aluminium, copper, iron, nickel, silver or gold or an alloy with those materials.

In that respect it is also possible for the reflection layer 74 to be shaped only partially and in a pattern configuration, that thereby providing an optical security element having region-wise transmissive or reflective properties.

The diffractive structures 761 and 762 are impressed into the regions 771 and 774 respectively of the stamping film 7. The diffractive structure 763 is impressed into the replication layer 73 in the regions 772, 773 and 774 of the stamping film 7. The diffractive structures 761 and 762 on the

one hand and 763 on the other hand are impressed into the replication layer 73 on opposite sides, in which case the diffractive structures 762 and 763 are in mutually superposed relationship in the region 774. The layer 74 is applied only region-wise to the replication layer 73 so that the diffractive structure 763 is coated with a layer of liquid crystal material, only in the regions 774 and 772.

That therefore affords the following different optical effects in the regions 771 to 774:

The diffraction effect produced by the diffractive structure 761 is involved in the region 761, so that here for example there is a reflective holographic representation. In the regions 762 and 773, the diffractive structure 763 produces, in mutually juxtaposed relationship, a polarisation representation and a holographic representation, both being reflective, as shown for example in the embodiment of Figure 6. In the region 774, the optical-diffraction effect produced by the diffractive structure 762 is superimposed with the polarisation effect produced by the layer 74 so that for example a holographic representation changes with a change in the polarisation direction of the incident light.

Figure 8 shows a sticker film 8 comprising six layers 81, 82, 83, 84, 85 and 86. The layer 81 is a carrier layer. The layers 82 and 85 are replication layers into which diffractive structures 87 and 88 respectively are impressed. The layer 83 is a layer of a liquid crystal material. The layers 84 and 86 are adhesive layers.

The layers 81, 82 and 85, 83 as well as 84 and 86 are for example like the layers 31, 32, 33 and 34 respectively in Figure 3.

The sticker film 8 is produced like the sticker film 3 in Figure 3. Then, the procedure involves laminating on to the film body produced in that way, the replication layer 85 with the diffractive structure 88 and the adhesive layer 86, for example by means of a laminating foil.

Besides the positioning of the diffractive structures 87 and 88 shown in Figure 8, it is also possible for the diffractive structures 87 and 88 to be positioned like the diffractive structures 763 and 761 respectively and 762 as shown in Figure 7 and to be combined with a partially shaped layer 83.

In that case, the layer structure shown in Figure 8 makes it possible to achieve the same effects as in the case of the layer structure of Figure 7.

It is further possible for the layer 83 to be arranged beneath the layer 85 so that the diffractive structure 87 only has an optical-diffraction effect.

Figure 9 shows an optical security element 9 which comprises five layers 91, 92, 93, 94 and 95. The layer 91 is a replication layer, into which a diffractive structure 96 is impressed. The layer 92 is a layer of a liquid crystal material. The layer 94 is a reflection layer. The layers 93 and 92 form a thin film layer system which produces colour shifts, in dependence on the angle of view, by means of interference. The layer 95 is an adhesive layer.

The layers 91, 92 and 95 are like the layers 23, 24 and 26 in Figure 2. The layer 94 is like the layer 75 in Figure 7.

The thin film layer system comprises an absorption layer (preferably with 30 to 65% transmission), a transparent spacer layer as a colour change-producing layer ($\lambda/4$ or $\lambda/2$ layer) and an optical separating layer (formation of a transmissive element) or a reflecting layer (formation of a reflective element). The thickness of the spacer layer in this case is so selected that, when a reflective element is produced, the $\lambda/4$ condition is satisfied and, when a transmissive element is produced, the $\lambda/2$ condition is satisfied, wherein λ is preferably in the range of light which is visible to a human observer.

The absorption layer can comprise for example one of the following materials or an alloy of the following materials: chromium, nickel, palladium, titanium, cobalt, iron, tungsten, iron oxide or carbon.

The optical separating layer can be in particular materials such as oxides, sulphides or chalcogenides. What is decisive in regard to the choice of the materials is that there is a difference in the refractive index, in relation to the materials used in the spacer layer. That difference should preferably be no less than 0.2. Depending on the respective materials used for the spacer layer therefore, an HRI material or an LRI material (HRI = High Refraction Index; LRI = Low Refraction Index) is therefore used.

It is also possible to make up a thin film layer sequence which produces colour shifts, in dependence on angle of view, by means of interference, from a succession of high-refractive and low-refractive layers. In a layer structure of that kind, it is possible to forego the use of an adsorption layer. The high-refractive and low-refractive layers of such a thin film layer sequence each form a respective, optically effective spacer layer which has to comply with the above-described conditions. The greater the number of layers selected, the correspondingly sharper is it possible to adjust the wavelength of the colour change effect. It is particularly advantageous in that respect for such a thin film layer sequence to be made up of 2 to 10 layers (even-numbered variant) or 3 to 9 layers (odd-numbered variant).

Examples of conventional layers of such a thin film layer sequence and examples of materials which can be used for the layers thereof are disclosed for example in WO 01/03945, page 5, line 30 to page 8, line 5.

In the region of the diffractive structure 96, in that way the optical interference effect produced by the thin film layer system 93 is overlaid by the polarisation effect produced by the layer 92. A colour change effect which is dependent on angle of view, being produced by the thin film layer system 93, thus occurs for example in dependence on the polarisation direction of the incident light, only for a partial region of the optical security element 9. It is also possible for the diffractive structure 96 and the layer 92 to be like the diffractive structure 68 and the layer 66 in Figure 6, thereby to attain a combination of diffractive effects, optical-diffraction effects and polarisation effects.

CLAIMS

1. A film (2, 3), in particular a stamping film, a laminating film or a sticker film, comprising a carrier layer (21, 31) and a replication layer (23, 32),

characterised in that

the film further has a layer (24, 33) comprising a liquid crystal material, which is applied to the replication layer (23, 32), and that impressed into the surface of the replication layer (23, 32) which is towards the layer (24, 33) of a liquid crystal material is a diffractive structure (27, 35) for orientation of the liquid crystal material, which structure has at least two partial regions with different orientation directions in respect of the impressed structure.

2. A film according to claim 1 characterised in that the diffractive structure has a region in which the orientation direction of the structure progressively changes and which is coated with the layer of a liquid crystal material.

3. A film according to claim 1 characterised in that the diffractive structure has adjoining regions with different orientation directions and which are coated with the layer of a liquid crystal material.

4. A film according to claim 1 characterised in that the diffractive structure (68) has a first region (62) for orientation of liquid crystal material, which is covered by the layer (66) of a liquid crystal material, and that the diffractive structure (68) has a second region (61, 63) for producing an optical diffraction effect, in particular for producing a hologram.

5. A film according to claim 4 characterised in that a polarisation representation produced in the first region (62) and a holographic

representation produced in the second region (61, 63) form a mutually supplementing representation.

6. A film according to one of the preceding claims characterised in that the diffractive structure has a region in which the diffractive structure (51 to 55) is formed from a superimposition of a coarse structure for producing an optical effect with a fine structure of higher spatial frequency for orientation of the liquid crystal material.

7. A film according to claim 6 characterised in that the fine structure has a period of less than 400 nm.

8. A film according to claim 6 characterised in that the spatial frequency of the fine structure is at least ten times higher than the spatial frequency of the coarse structure.

9. A film according to one of claims 6 to 8 characterised in that the coarse structure is a light-scattering structure, in particular an isotropic matt structure with a period of 500 nm to 1 μm.

10. A film according to one of claims 6 to 8 characterised in that the coarse structure is a macrostructure with a spatial frequency of less than 300 lines per mm.

11. A film according to one of the preceding claims characterised in that the diffractive structure has a region in which the diffractive structure is formed from a superimposition of a first structure for producing an optical effect with a second structure of greater profile depth for orientation of the liquid crystal material.

12. A film according to claim 11 characterised in that the profile depth of the second structure is at least 100 nm greater than that of the

first structure, wherein the profile depth of the first structure in particular is of a value from the range of 250 nm to 400 nm.

13. A film according to one of the preceding claims characterised in that the layer of a liquid crystal material covers the diffractive structure in region-wise fashion in a pattern configuration.

14. A film according to one of the preceding claims characterised in that one of the layers, in particular the liquid crystal layer, is of differing thickness in region-wise manner.

15. A film according to one of the preceding claims characterised in that iridescence or kaleidoscope effects are achieved by purposeful variations in orientation of the structured layer.

16. A film (2, 3) according to one of the preceding claims characterised in that the film has a protective lacquer layer (25, 34) covering the layer (24, 33) of a liquid crystal material.

17. A film (8) according to one of the preceding claims characterised in that the film (8) has a further layer (85) with a further, optically effective, diffractive structure (88).

18. A film (7) according to one of the preceding claims characterised in that a further, optically effective, diffractive structure (762, 761) is impressed on the surface of the replication layer (73), which surface faces away from the layer (74) of a liquid crystal material.

19. A film according to claim 17 or claim 18 characterised in that the further, optically effective, diffractive structure overlies the diffractive structure at least in a region-wise manner.

20. A film according to one of claims 8 to 10 characterised in that the further, optically effective, diffractive structure only partially covers the further layer or the replication layer.

21. A film according to one of the preceding claims characterised in that the film has a thin film system (93) for producing colour shifts by means of interference.

22. A film according to claim 21 characterised in that the thin film system (93) overlies the diffractive structure (96) at least in region-wise manner.

23. A film according to one of the preceding claims characterised in that the transfer film has a reflecting layer, in particular a metallic layer or an HRI layer.

24. A film according to claim 23 characterised in that the reflecting layer is partially provided.

25. An optical security element (11, 12; 4) for safeguarding banknotes, credit cards and the like, wherein the optical security element (11, 12; 4) has a replication layer (42),

characterised in that

the optical security element (11, 12; 4) further has a layer (43) comprising a liquid crystal material, which is applied to the replication layer (42), and that impressed into the surface of the replication layer (42) which is towards the layer of a liquid crystal material is a diffractive structure (46) for orientation of the liquid crystal material, which structure has at least two partial regions with different orientation directions in respect of the impressed structure.

26. An optical security element according to claim 25 characterised in that the optical security element is a two-part security element, wherein

a first partial element (11) has the replication layer and the layer consisting of a liquid crystal material and the second partial element (12) has a polariser for checking the security feature produced by the layer of a liquid crystal material.

27. An optical security element according to claim 25 characterised in that the optical security element is a two- or multi-part security element comprising two or more partial elements, wherein both a first partial element and also a second partial element has a layer of a liquid crystal material, which is applied to a replication layer, into which is impressed a diffractive structure for orientation of the LCP material, and which has at least two partial regions with different orientation directions in respect of the impressed structure, and that the second partial element serves for checking the security feature produced by the first partial element.

Abstract

The invention concerns a film (2), in particular a stamping film, a laminating film or a sticker film, and an optical security element. The film (2) has a carrier layer (21) and a replication layer (23). The film further has a layer (24) of a liquid crystal material, which is applied to the replication layer. Impressed into the surface of the replication layer, which is towards the layer of a liquid crystal material, is a diffractive structure (27) for orientation of the liquid crystal material, which has at least two partial regions with different orientation directions in respect of the impressed structure.

(Figure 2)